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Effect of Crack Size on Initiation and Growth Behavior in a Particulate Composite Material

C. T. Liu
&
T. C. Miller
Air Force Research Laboratory
AFRL/PRSM
10 E. Saturn Blvd.
Edwards AFB CA 93524-7680

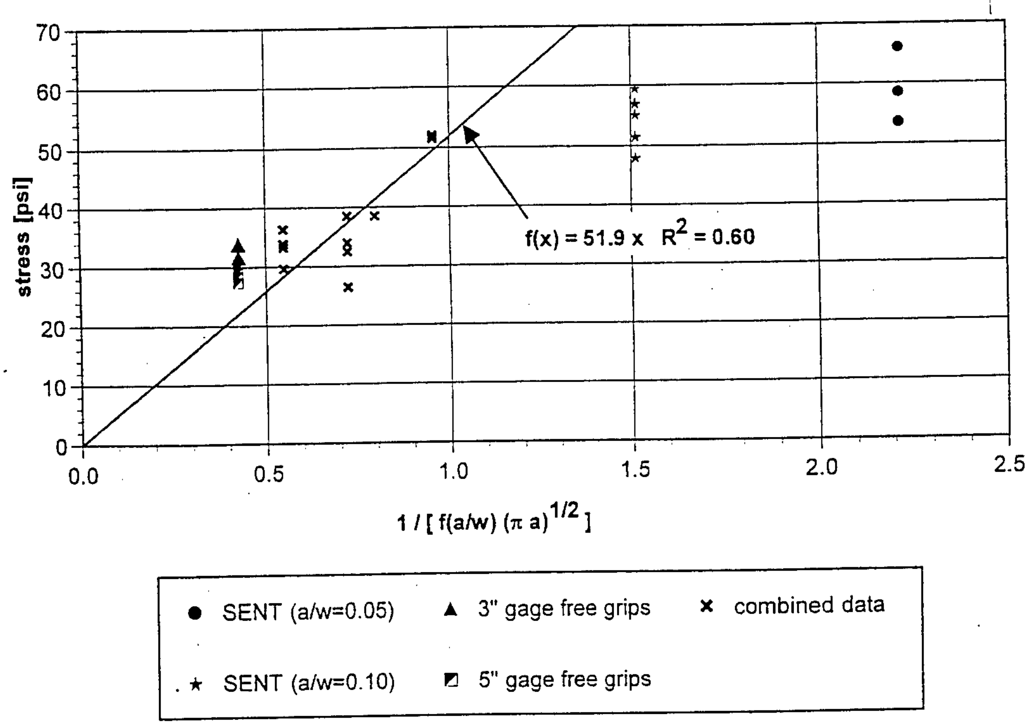
An important engineering problem in structural design is evaluating the strength and reliability of the structure. It is well known that the strength of a structure may be degraded during the period of its design life under service loads. One of the common causes of strength degradation is the result of the development of cracks in the structure. However, the development of cracks in a structure does not necessarily mean that the service life of the structure is terminated. Therefore, to determine the ultimate strength or the ultimate service life of a structure, studies should be conducted to determine the significance of flaw types and size as well as the rate of growth.

In recent years, a considerable amount of work has been done in studying crack growth behavior of long cracks in particulate composites [1-4] . These materials consist of hard particles contained in a soft binder. The basic approach used in characterizing the crack growth behavior in these materials is based on linearly elastic or linearly viscoelastic fracture mechanics. It is known that classical fracture mechanics principles, especially linearly elastic fracture mechanics, including small scale yielding, are well established for single-phase materials. However, experimental data indicate that linearly fracture mechanics theories were applied to particulate composite materials with varying degrees of success.

In this study, single-edge notched tensile specimens made from polybutadiene rubber embedded with hard particles were used in crack propagation tests. The specimens were 1.0 in. wide, 3.0 in. high and 0.2 in thick. Five initial crack lengths (0.05 in.,0.1 in. ,0.2 in., 0.3 in., and 0.4 in.) were considered. The pre-cracked specimens were tested at 0.2 in/min displacement rate at room temperature. The raw data obtained from the tests were the crack length a; the time, t; and the load ,p, corresponding to the measured crack length. These raw data were used to calculate the crack growth rate, da/dt, and the Mode I stress intensity factor ,K_I. The applicability of using linearly fracture mechanics to calculate K_I for the initiation and the subsequent growth of the crack is discussed. In addition, the growth behavior of the short and the long cracks were compared and the results are discussed.

Critical stress intensity factors, K_{Ii}, for the onset of crack growth were calculated, based on linear fracture mechanics. The experimental results indicate that, for a given initial crack length crack, the variations of K_{Ii} among different specimen thicknesses are within experimental scatter. Therefore, as a first approximation and for engineering applications it can be assumed that K_{Ii} for the onset of crack growth is independent of specimen thickness. The average values of K_{Ii} are 52.75 psi $(in)^{1/2}$ and 35.16 psi $(in)^{½}$ for initial crack lengths equal to 0.3 in. and 0.1 in., respectively. In this study, nonlinear fracture mechanics was also used to calculate K_{Ii}. The values of K_{Ii}.are 49.26 psi$(in)^{1/2}$ and 32 psi$(in)^{1/2}$

[4] Liu, C.T. and Smith,C.W.," Temperature and Rate Effects on Stable Crack Growth on a Particulate Composite Material," Journal of Experimental Mechanics, Vol.36-No.3, 1996.



Figvre 1 Plot of applied stress at crack initiation versus1 / [f(a/w) (π a)$^{1/2}$].

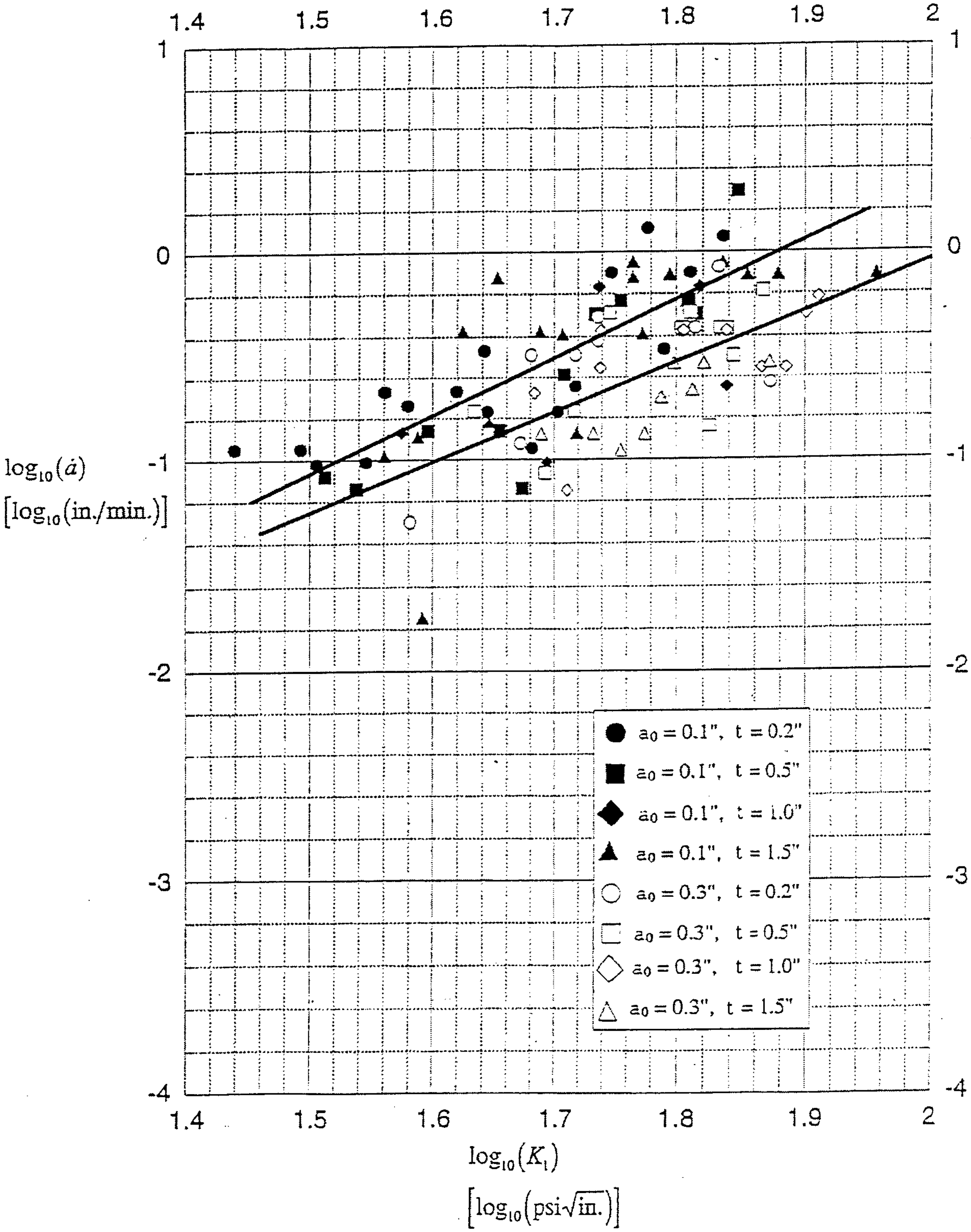


Figure 2. Crack growth rate versus Mode I stress intensity factor for different Initial crack lengths and specimen thicknesses.